Image Processing Algorithms and the Digital Image Path

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Abstract

The digital image path encompasses a multiplicity of functions such as scanning, importing, printing, copying, and faxing of images. As such, a variety of computations is required to transform such diverse inputs to a form suitable for output on a raster display or printer. These computations frequently involve colorimetric and spatial image processing algorithms such as color calibration, color transformation, segmentation, compression, filtering, halftoning, rasterization, etc. This talk examines a number of representative pathways through the digital image processing pipe and elaborates on some of the more typical algorithms involved.

Imaging Scenarios

The scope and diversity of the digital image path can be illustrated by examining a number of representative imaging scenarios such as scanning, printing, and copying.

Scanning is typical of digital image capture, which includes digital photography and videography. An original document (or scene) is sampled by a sensor array, such as a CCD. The resulting image raster is then processed to equalize illumination falloff and reduce noise. Gamma correction may also be applied to obtain a perceptually relevant dynamic range, and the color signal is frequently converted to a standard color space such as sRGB for storage and display.

Printing normally entails mapping an internal object-based representation of a document to a raw raster or to a sequence of printer control codes that allow the image to be properly rendered on the output device. Other talks deal more thoroughly with the hardware and software intricacies of this rasterization problem; for our purposes we assume the image raster. One key computation then is the color transformation of the image from a sensor-oriented color space such as RGB to the CMYK of the output device. This involves issues of gamut mapping and under color removal (UCR). A second key computation is the conversion of a multilevel image to an equivalent binary form via digital halftoning.

Digital copying can be thought of as coupling scan and print functions with a rather sophisticated image processing pipeline. The pipeline transforms the digital image raster in a sequence of colorimetric and spatial image-processing steps that typically incorporate computations such as scaling, filtering, segmentation, and compression. Certain of these computations are designed to improve output copy quality by, for example, increasing the legibility of text, reducing moiré, and enhancing color fidelity. Other computations provide specific copier features such as digital magnification and so-called scan-once-print-many (SOPM) functionality.

Segmentation

Segmentation has emerged as a critical technology in many areas of digital imaging and video, because it supports selective processing which can result in improved quality and performance. In digital copiers for example, segmentation can improve overall image quality by explicitly identifying significant elements in the input that require diverse and specialized treatment with respect to filtering, halftone generation, and even marking strategies. Similarly, segmentation can greatly improve compression ratios while preserving image quality by selecting, for each particular area of the image, the compression method best suited to the content of that region.

Biography

John Dolan received a BFA from Pratt Institute and worked for more than 10 years as a Graphic Arts Specialist. He earned MS and PhD degrees in Computer Science from the University of Massachusetts with a focus in Computer Vision. He has worked on a number of large-scale image-understanding tools and has designed and built semi-automated tools for graphic artists. He is currently a researcher at Sharp Laboratories of America in Camas, WA. His research interests include segmentation, perceptual grouping, and computational geometry.